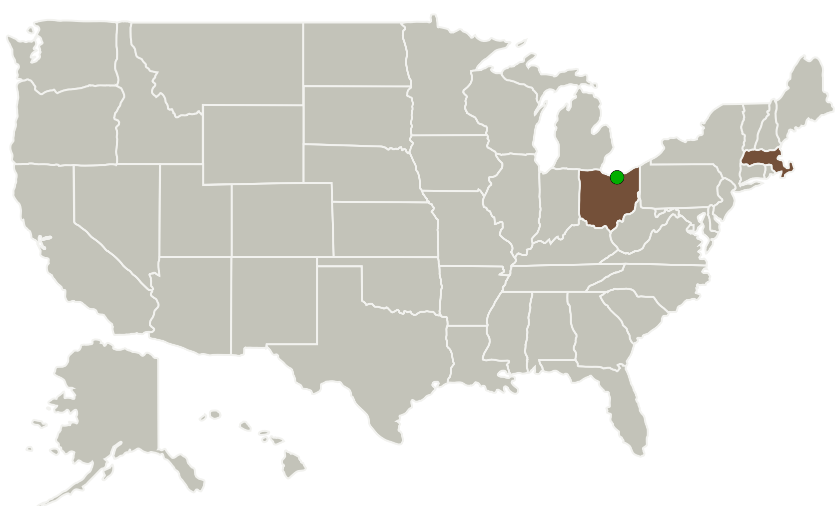
A Ferroelectric Semiconductor Absorber for Surpassing the Shockley-Queisser Limit, Phase I

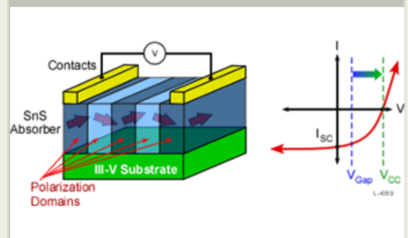
Completed Technology Project (2017 - 2017)

Project Introduction

Physical Sciences Inc. (PSI) proposes to develop new solar cells based on a ferroelectric semiconductor absorber material that can yield a 30% increase in efficiency and a 20% increase in specific power compared with current triple-junction III-V cells. These gains will be realized by exploiting a unique charge separation mechanism in ferroelectrics that enables open-circuit voltages many times the band gap, leading to maximum power conversion efficiencies exceeding the conventional Shockley-Queisser limit (33%). PSI and team members will create photovoltaic cells based on Earth-abundant SnS stabilized in a ferroelectric state by epitaxial strain engineering. By combining above-gap cell voltages with the high absorption coefficient (<1 x 105 cm-1 at 500 nm), low density (5.22 g/cm3), and ideal band gap (1.1 eV) of SnS, a mass-specific power density of 120 kW/kg (mass of absorber material, 1 um absorber thickness) is projected. In addition, a maximum cell efficiency of >45% is anticipated to be achievable. Importantly, these cells will also offer improved radiation resistance due to the reduced carrier diffusion lengths required by the unique ferroelectric charge separation mechanism. During Phase I, PSI, guided by first-principles calculations conducted by the PARADIM Center at Cornell University, will demonstrate room-temperature ferroelectric ordering in SnS through epitaxial strain engineering. During Phase II, PSI and Lawrence Berkeley National Laboratory will demonstrate the potential of the proposed absorber by achieving above-band gap open-circuit voltages in prototype cells. During a Phase III effort, the efficiency of these cells will be increased to a target value of 45% through reduction of intrinsic defects, leading to substantial improvements in cell size, weight, and power output.

Primary U.S. Work Locations and Key Partners





A Ferroelectric Semiconductor Absorber for Surpassing the Shockley-Queisser Limit, Phase I Briefing Chart Image

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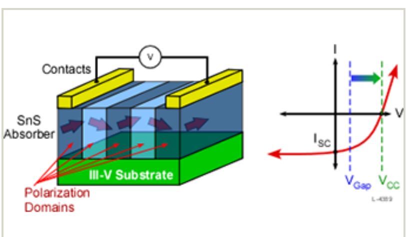
Completed Technology Project (2017 - 2017)

Organizations Performing Work	Role	Type	Location
Physical Sciences, Inc.	Lead Organization	Industry	Andover, Massachusetts
Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
Massachusetts	Ohio

Images



Briefing Chart Image
A Ferroelectric Semiconductor Absorber for Surpassing the Shockley-Queisser Limit, Phase I Briefing Chart Image
(https://techport.nasa.gov/image/130024)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Physical Sciences, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Mark J Polking

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX03 Aerospace Power and Energy Storage
  └─ TX03.1 Power Generation and Energy Conversion
    └─ TX03.1.1 Photovoltaic

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System